THE NATURE CONSERVANCY NEWS

November/December 1983

WHAT'S A SPECIES WORTH?

The rosy periwinkle fights leukemia.

Robert Perdue (USDA)

If we save wild species,
maybe they'll save us.

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THE NATURE CONSERVANCY NEWS

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The Nature Conservancy

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COVER: Relatives of modern corn from the Valley of Mexico: *Zea mays mays* at left and *Zea mays mexicana* (Chalco teosinte) at right. The successful breeding of corn with a wild, virus-resistant perennial teosinte holds promise for crop improvement. Photo by Hugh H. Iltis.

The Nature Conservancy is a national conservation organization committed to the preservation of natural diversity by protecting lands supporting the best examples of all components of our natural world.

To date the Conservancy and its members have been responsible for the preservation of 2,060,653 acres of forests, marshes, prairies, mountains, deserts, and islands: home to rare and endangered species of wildlife and plants. 3,199 projects have been completed since the acquisition of the first preserve in 1954. Approximately 60% of all preserves are retained by the Conservancy and managed by staff and volunteer land stewards.

A nonprofit membership organization, the Conservancy was incorporated in 1951 in the District of Columbia for scientific and educational purposes.

A copy of the last financial report filed with the Department of State may be obtained by writing to: New York State, Department of State, Office of Charities Registration, Albany, New York 12231, *or* The Nature Conservancy, 1800 North Kent Street, Arlington, Virginia 22209.

An Introduction by Edward O. Wilson

Baird Professor of Science, Harvard University

THINK OF SCOOPING UP a handful of soil and leaf litter and placing it on a white cloth —as a field biologist would do—for closer examination. This unprepossessing lump contains more order and richness of structure, and particularity of history, than the entire surface of all the other (lifeless) planets. It is a miniature wilderness that would take almost forever to explore, should we choose to make the organisms in it the objects of serious biological study. Every species living there is the product of millions of years of history, having evolved under the harshest conditions of competition and survival. Each organism is the repository of an immense amount of genetic information.

The abundance of the organisms increases downward, according to size, like layers in a pyramid. The handful of soil and litter is home for dozens of insects, mites, nematode worms, and other small invertebrates, most of which are just visible to the naked eye. There are also about a million fungi and ten billion bacteria, mostly microscopic. Each of the species has a distinct life cycle fitted to a portion of the micro-environment in which it thrives and reproduces. The individuality of each is programmed by an exact sequence of nucleotides, the ultimate molecular units of the genes. These species have evolved as independent elements for thousands of generations.

For the sake of illustration, let us use the "bit," the smallest unit of information content used in computer science, to measure the amount of genetic information contained in an organism. (One bit is the information required to determine which of two equally likely alternatives is chosen, such as heads or tails in a coin toss.) A single bacterium possesses about ten million bits of genetic information, a fungus one billion, and an insect from one to ten billion bits according to species. The information content of the English language, however, averages only two bits per letter. Therefore, if the amount of information in just one insect—say an ant or a beetle—were to be translated into a code of English words and printed in letters of standard size, the string would stretch over a thousand miles. The life in our little sample of litter and soil would just about fill all the published editions of the Encyclopaedia Britannica.

A single bacterium possesses about ten million bits of genetic information, a fungus one billion, and an insect from one to ten million.

With so much structure and order—and potential—packed into such a small space, it is staggering to contemplate the whole genetic content of a nature preserve or, even more, of an ecosystem. The ultimate *value* of the organisms in a reserve, therefore, is beyond measure, especially at sites harboring rare and endangered species. Most biologists estimate that there are between three and ten million species of plants, animals, and microorganisms on Earth. But there are additional sound reasons, based on new data from tropical forests, to place the figure at closer to 30 million. In fact, the exact number cannot even be guessed because, incredibly, most species have yet to be discovered. Among those already classified, no more than a dozen have been studied in as much detail as the fruit fly, the horse, or maize. And experts are quick to point out that the biology of even these paradigms remains poorly explored.

Such estimates and the uncertainties surrounding them are among the reasons that professional ecologists are often the most committed conservationists. They recognize that the accelerating destruction of natural habitats and the extinction of species is eliminating important opportunities for future biological research. We are rapidly narrowing not only potential scientific knowledge but also the commensurate benefits these species might have for the human race.

To take a practical example, Norman Myers has estimated that societies around the world use about 7,000 kinds of plants for food and have come to depend—to a frightening degree—on about 15 highly domesticated forms. Yet at least 75,000 species exist that are edible, and even the relatively modest amount of research on plant diversity conducted thus far has revealed many among these that are potentially superior to the crop plants in prevalent use.

THE RELATION OF the human spirit to the diversity of life is equally important, though much more difficult to express using case histories and logical argument. Belief in the preservation of species diversity is consistent with an optimistic view of the future of our own species. It appears to be within the reach of human genius to thread the needles of technology and politics. Suppose, for the sake of argument, that a worldwide utopia of the practical, physical kind is attainable. If people could indeed be adequately fed, medicated, and housed—in balanced populations—and safeguarded from nuclear war, they would be able to turn at last to total personal fulfillment and the realization of individual potential. But what is fulfillment? And to what end does human potential exist? It is when these surprisingly difficult questions are more fully addressed that the ultimate value of organic diversity becomes clearer.

I believe that the more the mind is studied scientifically, as an organ for survival, the greater will be our reverence for life, for reasons that can be expressed in clear, rational terms. There is abundant evidence already that the urge to explore and affiliate with other organisms is a deep and complicated process in mental development. Life in any form is far more interesting than almost any conceivable kind of inanimate matter, and the latter is valued to the extent that it can be metabolized into live tissue, can accidentally resemble it, or can be fashioned into a useful and properly animated artifact. No one in his right mind, to put an admittedly fine point on the matter, would prefer a pile of dead leaves to the tree from which they fell.

Novelty and diversity are particularly esteemed for the unlimited future they imply, and they are worth a very great price to keep.

From infancy we concentrate happily on ourselves and other organisms. We learn to distinguish life from the inanimate and move toward it like moths to a porch light. We have a natural tendency to seek an ideal environment rich in plants and animals, and we turn unconsciously to other organisms for a sense of kinship, religious symbolism, and metaphor. To an extent still undervalued in philosophy and religion, our existence depends on our propensity to regard life in this way. Our spirit is woven from this inner drive, and our finest hope rises on its currents. Novelty and diversity are particularly esteemed for the unlimited future they imply, and they are worth a very great price to keep. Those with the foresight to preserve even a small part of this heritage will be remembered far longer than those who destroy the rest.

Dr. Wilson, a specialist on the ecology of diversity and the social behavior of animals, is the author of *The Insect Societies* (1971), *Sociobiology: The New Synthesis* (1975), and *On Human Nature* (1978), which won the Pulitzer Prize for General Non-Fiction in 1979. He is currently working on a book analyzing the biological and psychological roots of the conservation ethic.

Agricultural Research Service (USDA)

Stoke's aster, ornamental plant of the Southeast, yields a seed oil rich in epoxy fatty acids for use in paints and other coatings. Opposite: puffer fish—source of a nerve-blocking agent—and Hawaiian monk seal.

Frans Lanting

By Saving Wild Species, We May be Saving Ourselves

by Norman Myers

THE RATIONALES FOR SAVING wild species, at the onset of the movement several decades ago, were largely ethical, esthetic, and ecological. These fundamental arguments have since been joined by another, equally important one. We depend on our fellow species for our material welfare, and ultimately for our future survival, in all sorts of unsuspected ways. Conserving the planet's tropical areas is especially important to realizing the utilitarian benefits of wild species. Some 70 percent of the Earth's plants and animals exist in the tropics, which means—by and large—in developing nations. Third World leaders may be personally aware of the ethical and esthetic values of wildlife, but they also recognize that it is politically unfeasible for their impoverished populations to retain space for rhinos, giraffes, and jaguars when millions of hungry people lack land to grow their crops. If wildlife can "pay its way" in the marketplace and make a local economic contribution, then space may yet be found for threatened species.

Although some may view the utilitarian rationale for preserving species as a narrow view of wildlife's true value, there need not be a conflict between the consideration of a species' economic contributions and the belief that its continued existence needs no justification. But faced with expanding human populations, especially in developing nations, we must realize there is less and less room for wildlife that exists for its own sake.

We use hundreds of products each day that owe their existence to plants and animals. The ways in which wild species support our daily welfare fall under three main headings: agriculture, medicine, and industry.

Hugh H. Iltis

Roots of Zea diploperennis, *the most primitive wild relative of corn, showing development of perennial rhizomes. This trait is coupled with natural immunities that make the species extremely desirable to corn breeders. Inset: a stand of the maize at its discovery site in Mexico's Sierra de Manantlán.*

Agriculture

The productivity of our major crops cannot be maintained, let alone expanded, without a constant infusion of fresh genetic variability. Much of this genetic material comes from wild plants, the relatives of modern crops. Indeed, the skills of plant geneticists, even more than the use of artificial additives such as fertilizers and pesticides, have yielded one record crop after another in North America.

Of course it is difficult to separate the contributions of genetic materials from other factors that enable certain crop variants to flourish. But as a rule of thumb—an exceptionally rough rule of thumb—agriculturalists estimate that, across the board, we can attribute some 40 percent of expanded productivity to genetic breeding, and hence to the germplasm and other genetic materials on which crop breeders depend.

For example, during the past several decades, plant geneticists and agronomists have enabled American farmers to produce over three times more corn per acre, until production has now surpassed 100 bushels per acre and occasionally reaches record levels of 240 bushels. Although a good part of this increased productivity can be attributed to massive amounts of fertilizer and pesticides, agricultural experts calculate that between two-fifths and three-fifths can be credited to the continuous redesign of corn's genetic composition.

At the same time, we should recall that high productivity of modern types of corn is often accompanied by high vulnerability to diseases, environmental stresses, and other problems of modern agriculture with its "streamlined" practices. The corn varieties that thrive tend to be planted everywhere corn will grow. By 1970, the parentage of seed corn used in the United States had become dangerously susceptible to disease. No less than 70 percent of the seed owed its ancestry to only *six* in-bred lines. Not surprisingly, a leaf blight struck, eliminating one-seventh of the entire crop and as much as one-half of the crop in southern states. As a result, corn prices rose by 20 percent, and the cost to farmers passed on to consumers totaled more than $2 billion. Fortunately, the situation was corrected with the help of blight-resistant germplasms whose genetic ancestry was originally derived from Mexico. Al-

though we cannot say that the critical genetic material was worth $2 billion, since other factors contributed to the turn-around (such as research facilities and the professional skills of plant breeders), the figure still gives us an idea of the huge sums of money that can be saved or lost.

Another new species of "wild" corn, or teosinte, was found more recently. Just a few years ago, a team of American and Mexican botanists, led by Professor Hugh Iltis of the University of Wisconsin and Rafael Guzman of the University of Guadalajara, discovered a wild plant in a remote montane forest in southwestern Mexico. This species, newly described as *Zea diploperennis,* is the most primitive known relative of modern corn. Only a few acres, no more than five or six, of the wild corn have been discovered, supporting a mere few thousand stalks. The plant's tiny relict habitat is threatened by timber cutters and settlers cultivating or grazing the surrounding land. (However, the recent efforts of Dr. Maria Luz Puga of the University of Guadalajara may result in preserving some of the corn's habitat in a scientific preserve.)

The significance of *Zea diploperennis* lies in its rhizomes, or underground stems, which make the plant a perennial. Conventional types of corn are annuals. This perennial trait offers all sorts of possibilities for America's corn-growing industry, which accounts for almost half the world's corn crop. Now that the wild species has been cross-bred with traditional corn, producing a perennial hybrid, some American farmers may eventually be able to grow their corn or at least their silage without the annual expense of plowing and sowing: the crop would come up by itself, year after year, just like daffodils. The amount of diesel fuel saved would be at least two-and-a-quarter gallons per acre each year, worth some $300 million. And when we consider the associated costs of plowing and sowing, the figure could—according to economist Professor Anthony Fisher of the University of California at Berkeley—soar beyond millions of dollars each year.

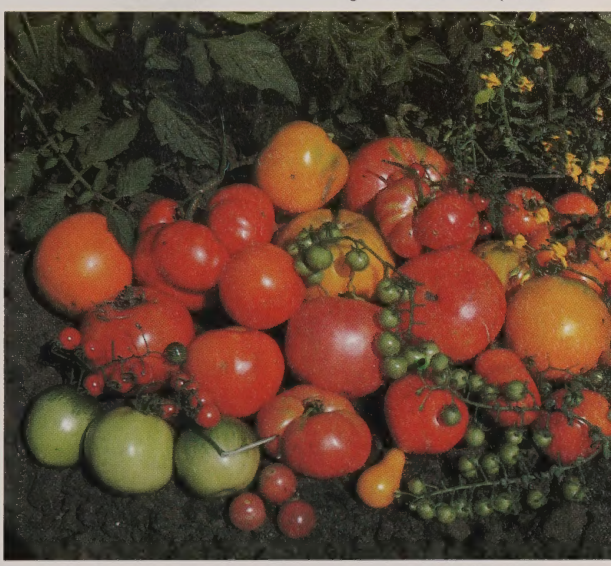
But even should the new hybrid prove less productive as a grain crop, the wild corn still could offer many benefits. Since is grows at elevations between 7,000 and 10,000 feet, its montane habitats are often damp and relatively cool. It is possible, then—even if a perennial variety is not as productive—to cultivate a cross-bred corn in areas where now existing annual corns cannot grow at all: in wet soils and chilly environments. This prospect alone could expand the overall range of corn cultivation by as much as one-tenth. Even if yields in these new environments were to average only one-half of those grown in more suitable areas, the additional harvest could be worth at least $1 billion per year.

More importantly, the Mexican corn also is highly immune to or tolerant of at least four of eight major viruses and diseases that now cause a one percent loss in the world's yearly corn yields —$500 million out of a total of $50 billion. Thus, the added resistance could save hundreds of millions of dollars each year. In addition, the perennial strain may supply genes resistant to various insects, nematodes, fungi, and bacteria, which could result in yet higher savings.

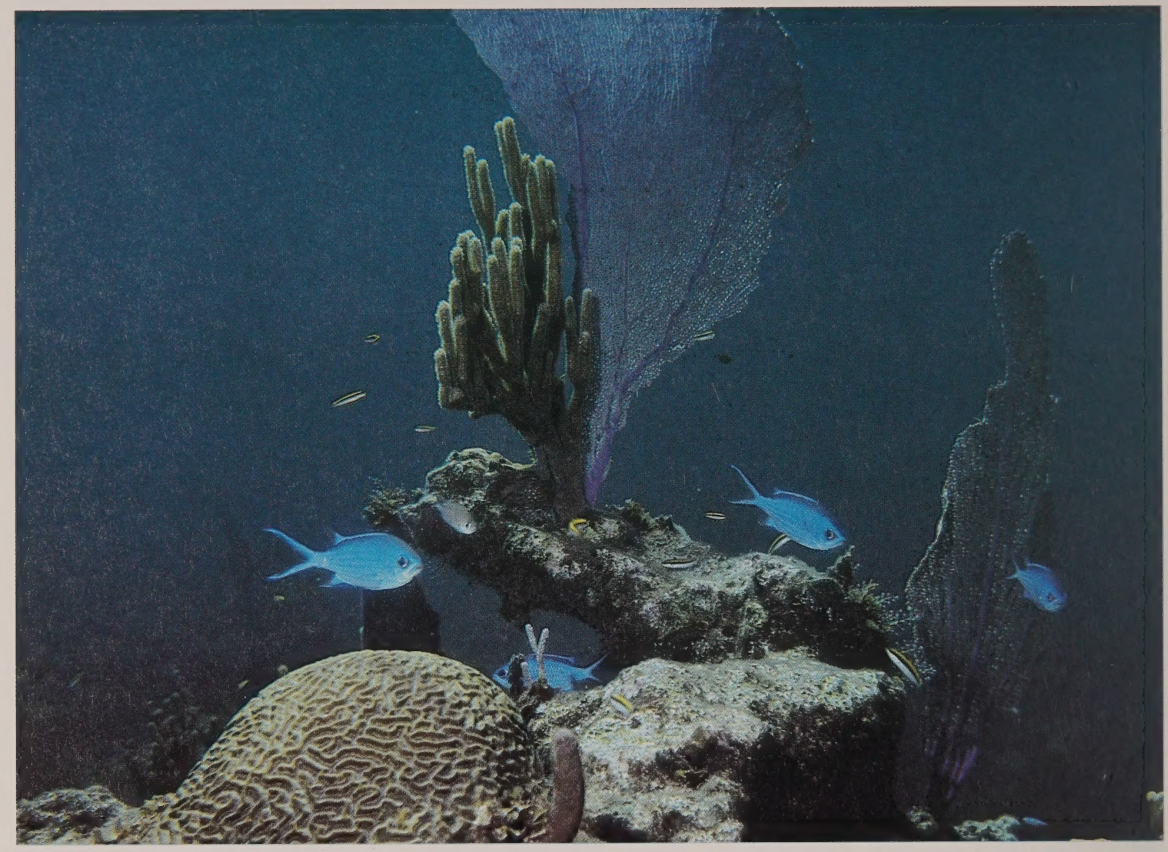
All of us enjoy the exceptional productivity of modern corn in many ways and by no means only when we eat cornflakes or popcorn. Bear in mind that corn is widely used to feed cattle, pigs, and poultry, and that corn sugar is contained in a variety of beverages, from beer to soft drinks.

There are similar stories about wheat, barley, tomatoes, oranges, and other modern crops. For example, the introduction of a wild wheat strain from Turkey that is resistant to several diseases has benefitted commercial species of U.S. wheat to the tune of around $50 million per year. Overall, the U.S. Department of Agriculture estimates that the annual farm-gate value of all America's crops is worth almost $100 billion. The department also calculates that yearly increases in productivity owing to genetic improvement average around one percent. This means that the value of such advances can be set at around $1 billion a year.

Ag. Research Serv. (USDA)



Familiar tomatoes, in a spectrum of genetic variations, dwarf their wild Andean relatives: Lycopersicon pimpinellifolium *(red, at left) and* L. peruvianum *(green, at right). The former's disease resistance and the latter's cold resistance are valued by plant breeders.*



Tony Arruza

Frans Lanting

Medicine

When we have a prescription filled at our neighborhood pharmacy, there is one chance in two that the medication we pick up owes its origins to "startpoint materials" from wild organisms. (A startpoint material is one that serves as the principal constituent in manufacturing a product, though by volume, it may amount to only a small part of the final medicine or drug.) The commercial value of these medicines and drugs in the U.S. now amounts to some $10 billion a year (1980 figure). If we extend the arithmetic to all developed nations, and include nonprescription materials plus pharmaceuticals, the commercial value tops $40 billion a year.

In 1960, a child suffering from leukemia had only one chance in five of remission. Now, thanks to drugs prepared from a tropical forest plant, the rosy periwinkle, the child has four chances in five. Commercial sales worldwide of the materials for drugs derived from this one plant currently total around $100 million a year. According to the National Cancer Institute and the Economic Botany Laboratory outside Washington, D.C., it is likely that the rain forests of Amazonia alone may well harbor several plants that contain ingredients for other anticancer drugs.

The value of plants to medicine cannot be overstressed. More than three million Americans with high blood pressure depend on regular doses of a cardiotonic compound called digoxin (300 times more powerful than digitalis), which is obtained from a Greek species of foxglove. A Brazilian plant is useful against amoebic dysentery; an ingredient from a semidesert shrub known in China serves as a nasal decongestant and as a stimulant for the central nervous system; ergot, a poisonous substance secured from a fungus, has long been used by midwives to speed labor and reduce bleeding. All in all, the plant kingdom offers agents for a broad range of medicinal and pharmaceutical products. Prime items include analgesics, antibiotics, drugs for heart diseases, anticancer agents, enzymes, hormones, diuretics, antiparasitic compounds, ulcer cures, dentifrices, laxatives, and anticoagulants.

Opposite: tropical coral reef (Bahamas) and tropical rain forest (Surinam). Tropical ecosystems, both marine and terrestrial, are surpassingly rich in organisms of interest to medical researchers. Many biochemical compounds available in these life forms serve as probes in experiments to study how the human body works.

The tropical coral reefs of the world abound with organisms that produce medicinal materials. Perhaps the most promising source of antiviral agents is a Caribbean sponge. It yields a compound effective against herpes encephalitis, a deadly brain infection that strikes many thousands of people each year. No useful drug had previously been known. Thus, much as penicillin did for diseases caused by bacteria, the sponge's compound may offer a breakthrough in treating diseases caused by viruses, including (perhaps) the common cold.

Similarly, sand fish, porcupine fish, and puffer fish yield tetrodotoxin, a toxic biocompound that blocks nerve transmission and has experimental value for medical researchers. The material is 160,000 times as potent as cocaine. The marine fish menhaden offers an oil that may aid in treating atherosclerosis; sea snakes yield an anticoagulant. Extracts from the toxin of the octopus not only relieve hypertension but could also be used as an anesthetic. The octopus paralyzes its prey by injecting a secretion from its salivary gland. Although the victim remains totally insensible, its heart continues to beat normally, indicating that the octopus's "poison" may be very helpful in modern surgery.

Perhaps the most important of all materials derived from marine life are those that serve as startpoint ingredients for anticancer drugs. These compounds come from corals, sea anemones, mollusks, segmented worms, sponges, sea cucumbers, proboscis worms, clams, and sea squirts. Some of these organisms yield extracts that delay or prevent the development of cancer in mice. Sea cucumbers and related species contain holothurin, a promising anticancer product. Even seaweeds yield compounds helpful in cancer therapy: patients treated with them find that their appetites improve, they are relieved of nausea, and they suffer less pain following surgery and radiation.

Not only do coral-reef organisms offer compounds for drugs and pharmaceuticals but, by serving as "models," they also assist scientists in basic medical research. Our knowledge of the human nervous system was acquired primarily by investigating the giant axon of squids and the neuronal apparatus of the electric eel. And we have greatly advanced our understanding of interrelationships between basic behavior and certain nerve circuits by examining the sea hare's nervous system.

Industry

The sources of many startpoint materials for industry also are found in tropical coral reefs. Seaweeds, for example, supply alginate compounds, which are used as stabilizers and emulsifiers. They contribute to literally hundreds of products—plastics, polishes, waxes, deodorants, detergents, soaps, shampoos, cosmetics, paints, dyes, paper products, fire-extinguishing foams, building materials, and lubricants and coolants used in oil drilling. Seaweed serves as a source of vitamin C, poultry meal, and meat and fish preservatives. It is used to grow bacteria, to keep toothpaste in the tube, to make ice cream smooth, to make puddings thick, and to help candy bars last longer.

Land plants make a major contribution to industry as well, and as technology advances—in a world growing short of just about everything except shortages—industry's need for new raw materials will grow, ever more rapidly. One category of products, lubricants, is exceptionally important. Because petroleum-based lubricants are increasingly expensive, there is a premium on finding substitute materials. Of 6,400 plants recently screened by the U.S. Department of Agriculture for new oils and waxes, among other products, 460 were judged to be promising. Principal candidates include a number of plants with oil-rich seeds, such as the buffalo gourd and the jojoba shrub of the deserts of northern Mexico and the American southwest, together with another plant of the same region—the guayule bush, which is a source of natural rubber. The liquid wax derived from jojoba seeds is equivalent in its lubricant capacities to sperm-whale oil and requires little refining. It is used in manufacturing high-performance lubricants, linoleum, printing ink, varnishes, shampoos, soaps, face creams, and other cosmetics.

Apart from lubricating oils and waxes, plants produce many more specialized materials, such as gums and exudates (the most well-known exudate is rubber), essential oils (such as those used for perfumes and flavorings), resins and oleoresins, dyes, tannins, vegetable fats, insecticides, and multitudes of other biodynamic compounds. Numerous wild plants offer potential for manufacturing fibers, detergents, starches, and even improved golf balls. We benefit from plant materials each time we wash our clothes, use a sunscreen lotion, paint a wall or varnish a table, travel in a plane propelled by jet engines, have the dentist make a mold of our teeth, receive a vaccination or immunization shot.

Given the rapid expansion of the global chemical industry, it is clear that we shall need many additional supplies of organic industrial chemicals. The worldwide chemical industry is already large, worth $300 billion a year. In the U.S. alone, production of synthetic organic chemicals totals around 85 million tons a year, of which plastics account for 15 million. All over the world, we now use 60 million tons of plastics each year (one-quarter of this total goes into packaging materials), together with other types of plastics ranging from Ultrasuede to artificial football-field turf. On top of our hefty appetite for plastics, we also consume large quantities of lubricants, adhesives, coatings, and thickeners.

The chemical industry continues to derive most of its raw materials from fossil petroleum. Almost one decade after OPEC (Organization of Petroleum Exporting Countries) started business, American chemical corporations obtain only three percent of their raw materials from alternative sources, like vegetable fats and oils. An American citizen now uses some 500 pounds of petrochemical products each year. But while most petrochemicals cost a mere three cents per pound in 1973, their price now, in the wake of OPEC, is around 22 cents per pound. By contrast, vegetable fats and oils, which cost about one cent a pound in 1973, have not even doubled in price. There is strong incentive for the chemical industry to move beyond the petroleum-dominated era.

Fortunately, almost all petrochemicals in question can be replaced by phytochemicals. We already use many vegetable oils—notably castor, linseed, and tung—exclusively for industrial products. In addition, a number of oils that are included in our daily diets contribute to industry as well: soybean, coconut, palm, peanut, and safflower oils.

Ag. Research Serv. (USDA)

Jojoba beans, from the bush (right) and shelled (left). "Liquid wax" from the jojoba, similar to sperm-whale oil but much purer, may be used to manufacture a range of products, from automotive lubricants to cosmetics.

Robert Perdue (USDA)

At left, Kenyan plant specimens are spread to dry before American scientists screen them for the presence of anti-cancer compounds. Only some ten percent of all higher plants have been studied for such values. Below, sugar cane—a critical Third-World crop—in blossom.

Tony Arruza

ALTHOUGH WILD SPECIES contribute many thousands of different materials for the products we use each day, scientists have conducted a cursory screening of only one plant species in ten and intensive screening of only one plant species in a hundred. As for the animal world, with at least ten and perhaps 50 times more species than the plant world's estimated 250,000, scientists have done little more than consider the more prominent and obviously promising candidates. If researchers were to undertake a comprehensive and systematic analysis of *all* known species, it is certain that they would uncover vast numbers of new materials to enhance our daily lives.

Indeed, the discoveries already made suggest that we should regard the world's wild species as invaluable resources. They exist in an abundance of uniquely different forms; but we can derive few benefits from them unless we save space—natural habitats in which they can survive—for each. To do so will be a wise investment in the future survival of all species, especially our own.

Dr. Norman Myers, a consultant on environmental issues and resource economics, is the author of *The Long African Day, The Sinking Ark,* and *A Wealth of Wild Species: Storehouse for Human Welfare.* His next book, *The Primary Source*—on tropical forests—will be published in early 1984 by W. W. Norton of New York.

Hugh Archer

The Conservancy's Bad Branch Gorge in southeastern Kentucky—an enclave of endangered species.

The Conservancy's Endangered Species Program

by J. Paul Eckhardt

DEEP IN THE COAL FIELDS of Kentucky, a rugged gorge hosts 16 rare plants and several rare mammals. Its waters are habitat for the arrow darter, a fish that is endangered nationwide and endemic to the state. Thousands of miles away, another tiny fish—the Borax Lake chub—finds its only home in Oregon's largest thermal lake. Also significant for its warm-water springs, Florida's Crystal River provides critical winter refuge for the imperiled West Indian or Florida manatee. And to the north, the windswept grasslands of Rhode Island's Block Island are a haven for the state's largest population of nationally significant bushy frostweed or rockrose. The island also boasts New England's only site for the Maryland golden aster and the sole confirmed location in the state for the upland sandpiper.

Preserving these areas and others that harbor an array of America's most threatened flora and fauna is the goal of The Nature Conservancy's $15-million Katharine Ordway Endangered Species Conservation Program. Initiated a year ago with a $5-million challenge grant from the Goodhill Foundation, this new effort will protect as many as 150 species of jeopardized plants and animals. The grant—which must be matched over three years with a minimum of $10 million contributed by individuals, foundations, and corporations—has enabled the Conservancy to begin the only private program now under way that is comparable in scale to present federal protection measures to safeguard endangered species habitat.

Katharine Ordway, conservationist and creator of the Goodhill Foundation, provided the inspiration and the initial resources for the highly successful National Critical Areas Conservation Program. While the Critical Areas Program continues to concentrate its resources on preserving larger examples of the nation's most threatened natural systems, the Endangered Species Program focuses on smaller remnants of quickly vanishing habitat types. Both efforts combine rigorous analyses of sound scientific data with innovative, cost-effective protection measures.

Information provided by natural heritage programs—ongoing inventories designed to catalog elements of biological diversity, state by state—indicates those species requiring immediate protection. These data, combined with similar facts from the best private and government sources and reviewed from a national perspective, enable the Conservancy to set preservation priorities for the Ordway Endangered Species Program. Not only does this process offer substantial assurance of safeguarding the country's most critically jeopardized plants and animals, but it also assists the organization in directing its limited resources to those habitats most in need of protection.

Targeted sites are protected and managed in the most cost-effective manner. Sanctuary boundaries are drawn to include only essential habitat. Conservation easements and gifts are encouraged, and the best possible prices are negotiated for outright purchases. Fund-raising campaigns are designed to identify the resources needed for each acquisition and to match individual project grants provided by the Goodhill Foundation. The goal of every campaign is to garner funds for the purchase price, as well as for acquisition and management expenses of each preserve. Although matching requirements will vary from project to project, the Conservancy overall must raise $2 for every $1 granted by the Goodhill Foundation.

SINCE THE INCEPTION of the Katharine Ordway Endangered Species Program, 15 separate projects across the country have been approved for protection through the program. Two are in Minnesota. The Straight River Wildflower Preserve supports 42 colonies of the state's only endemic plant species, the dwarf trout lily (*Erythronium propullans*). This represents 10 percent of the plant's known colonies. Endangered in Minnesota, as well as throughout its range, the piping plover finds refuge at the Pine and Curry Island Preserve. The sanctuary hosts the largest number of breeding piping plovers in the Midwest and the only population in the Great Lakes region that is

not declining. Here the Conservancy is purchasing a key nine-acre inholding.

In neighboring Iowa, the Conservancy is continuing to add critical lands to the Charles and Anna Roggman Boreal Slopes Preserve. Fractures in the rocks beneath this steep limestone slope create a subterranean cooling system that sustains northern plant species beyond their normal range. Among these are dwarf scouring-rush, twinflower, bunchberry, and limestone oak fern—all listed as endangered in the state. But even more significant is the site's healthy stand of northern wild monkshood (*Aconitum noveboracense*), federally listed as an endangered plant species.

Jim Brandenburg

Piping plover on minimal nest with maximal eggs! The Conservancy's Pine and Curry Island Preserve protects critical breeding grounds for the jeopardized birds.

Safeguarding rare plants is also a goal of the Conservancy's Maryland Natural Areas Campaign, a three-year $1.2-million effort. A number of the campaign's projects also qualify for protection through the Ordway Endangered Species Program. Among these are Delmarva bays: small, pondlike acidic wetlands whose waters rise and fall with the seasons. The fluctuating water levels in these clay-based depressions have fostered the growth of several uncommon plants, including Torrey's dropseed (*Muhlenbergia torreyana*)—one of America's rarest plants—and dwarf fimbristylis (*Fimbristylis perpusilla*). Other Maryland preserves will safeguard sensitive joint-vetch (a bushy, delicate-leaved member of the pea family currently known from only four other sites in the world), harperella (a small member of the parsley family), and drowned beakrush (a sedge that sports unusually long bristles or beaks on its fruit).

Animals are the primary protection target at Bad Branch Preserve in Kentucky, where the area's topographical diversity has fostered an extraordinarily rich flora and fauna. Not only does Bad Branch Creek harbor the endemic arrow darter, but also its streamsides are habitat for threatened pigmy shrews, long-tailed shrews (which are endangered in the state), masked shrews, woodland jumping mice, and cloudland deer mice. The latter three species are extremely uncommon in Kentucky. To preserve this critical habitat, the Conservancy has purchased 548 acres; but a greater challenge remains—to acquire an optioned 257 acres in the biological heartland of the gorge.

The endangered, endemic chub is the highlight at Borax Lake in Oregon. But the lake itself is an outstanding natural feature, isolated in an arid landscape. Because it is fed by thermal underground springs, so its waters do not freeze, the lake is a significant wintering site for waterfowl. Along with the surrounding land, it provides essential nesting habitat for willets, phalaropes, long-billed curlews, and other shorebirds, as well as Canada geese and marsh hawks. Populations of the western whiptail and leopard lizard are found on the preserve, occurring at the northern end of their ranges.

The Garden of Eden is not a wildlife film.

The planned development of a portion of Florida's unique Garden of Eden region is used as a case study. Representing sanctuaries worldwide, the Garden of Eden, with its uncertain future, illustrates the possible conflict between the unknown—but potentially great—benefits of an untouched area and the demand for regional growth. The film demonstrates that access to accurate ecological information and cooperation—rather than confrontation—among conservationists, government, and industry are essential to making balanced decisions.

The Garden of Eden examines the rationale underlying today's hard conservation choices and suggests a positive workable approach for the future. The film says clearly that in making these choices, we are the single species with the most to gain—and to lose.

important conservation film for today.

". . . What is disappearing is . . . our long range economic insurance."
Dr. Thomas Eisner, Cornell University

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The Nature Conservancy

The Nature Conservancy depends on the support of its members to protect endangered species of plants and animals and to safeguard natural ecological systems.

The Conservancy is a nonprofit conservation organization whose resources are devoted to the preservation of natural diversity through the protection of habitat. The organization and its members have been responsible for the preservation of 2 million acres, comprising more than 3,200 conservation projects, throughout the United States, Canada, Latin America, and the Caribbean.

The organization also works with state governments to determine what is rare within a state and what needs to be protected. Additionally, the Conservancy maintains the largest private system of natural area sanctuaries in the nation.

You are invited to share in the action and the accomplishment by joining The Nature Conservancy. Membership produces conservation results you can count on.

I want to protect the diverse natural world while we have time and a chance for success. Please enroll me as a member of the Conservancy.
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Production and distribution of
THE GARDEN OF EDEN
were made possible by a grant from
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THE GARDEN OF EDEN
is a Florentine Films production
produced and directed by
Lawrence R. Hott
Roger M. Sherman

Executive Producer
Jack Lynn

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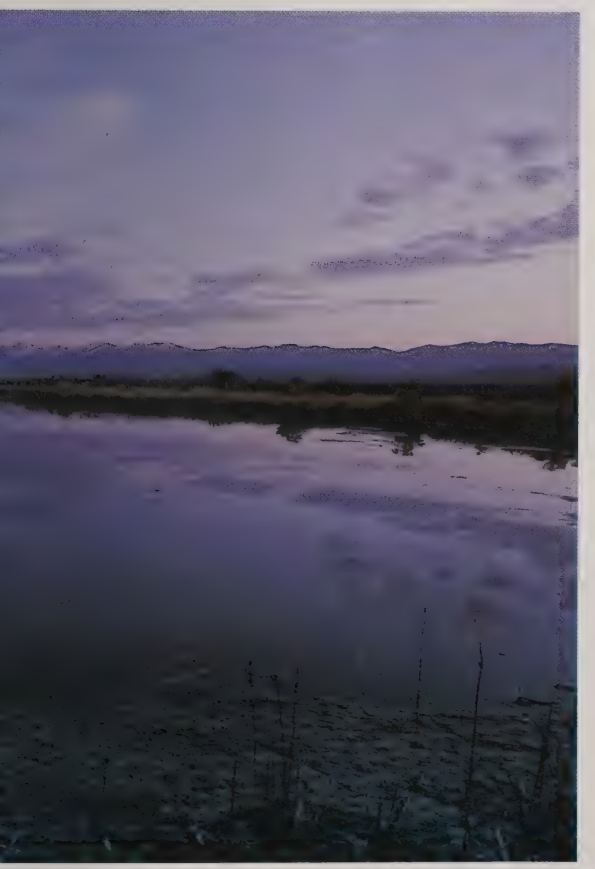
THESE ARE EXAMPLES of critical habitats the Conservancy has undertaken to protect through its Katharine Ordway Endangered Species Conservation Program. As the program develops, many others will be added to the effort. None will be protected without the concerted effort of Conservancy volunteers and members. But can we do less? The fate of many American species now hangs in the balance. We fear that many will follow the path of the passenger pigeon—as stuffed relics in a museum, grim symbols of our inability to protect the natural world. With your assistance, the Katharine Ordway Endangered Species Conservation Program can help ensure that this does not occur.

Larry Stone

Below: evening at Oregon's Borax Lake, the world's only habitat for a nationally endangered fish species. At left, another nationally endangered species—northern wild monkshood—at the Conservancy's Roggman Boreal Slopes Preserve in Iowa.



Gary Braasch

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IN THE SPIRIT OF KATHARINE ORDWAY

Biologist, land planner, philanthropist—Katharine Ordway was one of the most skilled and dedicated conservationists of our century. Her vision and support continue to propel many of The Nature Conservancy's most ambitious land conservation initiatives.

Last year, to honor Miss Ordway and to encourage others to follow her example, the Conservancy's Board of Governors created the Katharine Ordway Associates Program.

Individuals or couples who contribute a minimum of $1,000 to the Conservancy's General Fund qualify as Associates for the year following their gift. Benefits include invitations to special tours of outstanding Conservancy preserves, with informal briefings by senior management and noted naturalists. In the program's first year, more than 275 Charter Associates helped forward The Nature Conservancy's mission—many at *sponsor* ($2,500), *patron* ($5,000), and *benefactor* ($10,000) levels.

We invite your participation as a Katharine Ordway Associate . . . to carry on her leadership and realize her vision.

J. Paul Eckhardt coordinates the Conservancy's Katharine Ordway Endangered Species Program and its National Critical Areas Conservation Program.

What a Species Needs to Survive

by Daniel Simberloff

ANY PLANT OR ANIMAL species has three fundamental requirements for survival. First is a sufficient amount of habitat to which it is adapted. Second is the presence of enough individuals of species to which it is ecologically linked. Third is a large enough extant population that the probability of extinction, which can never be completely eliminated, is minimized. Long and tedious research is often needed to determine what habitat is appropriate for a species and to unravel the subtle linkages between that species and others within its community. Once this knowledge is available, still more research is required to ascertain: 1) how large a population must be to lower the probability of extinction to an acceptable range; and 2) how much habitat is required to support such a population. Though gathering this much information may sound like a tall order for the world's ecologists, it has already been done for some species, and it is possible to do the same for any other species given the necessary commitment of resources. What we learn about each also will speed—but not obviate—our research on others.

Every species is restricted to a certain range of characteristic physical habitats. Some limitations are easily recognized. For example, many epiphytes are restricted to the tropics, while many lichens thrive only in cold climates. Other habitat restrictions are subtler. The advent of acid rain revealed that many freshwater fishes have strict limits to the level of acidity they can tolerate. Limitations that involve *interactions* of physical factors are the most difficult to discern. For example, when some grasses are growing in habitats with superabundant nitrogen, their ability to withstand drought is increased. In other words, one cannot automatically characterize suitable habitat for a species by a series of single-factor ranges, such as those of temperature, moisture, and calcium concentration.

Even common, widespread species are limited to a range of habitats. Recent research shows that the wood thrush (*Hylocichla mustelina*), a ubiquitous bird of eastern deciduous forests, is restricted to regions with certain canopy heights and densities of plants. The American beech, *Fagus grandifolia,* is common throughout the eastern United States; but, though there are no obvious barriers to its southward distribution, its range ends in northern Florida. In the Midwest, the tree ceases to occur in eastern Illinois, again without apparent obstacles to further dispersal. It is virtually certain that the beech is restricted southward and westward not by an inability to disperse viable seeds but by the unsuitability of the habitat. Subtle thresholds have been reached. While water loss may act on seedlings to prevent westward expansion, the reason for the southern restriction is more elusive. It may involve a combination of factors—water, temperature, and soil nutrients.

IF COMMON SPECIES are limited to certain habitats, it is not surprising that rarer species have even stricter habitat requirements. Sometimes these needs can be met at very few sites. Oconee-bells (*Shortia galacifolia*) require wooded, moist ravines. *Dendroica angelae,* Puerto Rico's elfin woods warbler, is restricted to elfin forest (dwarfed and humid) found at only two sites in Puerto Rico. If conservation measures were required for wood thrushes or beeches, one could select from among many suitable areas. But for oconee-bells and the elfin woods warbler, only a few sites contain suitable habitat. Thus, to protect these species, we have few choices.

For many animals and some plants, such as forest understory herbs, certain (other) plant species constitute a major part of the physical habitat. For example, trees provide shade, determine temperature and humidity, modify wind patterns, and

so on. But species interact in many other ways, and for some the interactions are crucial to survival. Many plants and their insect pollinators are thus inextricably linked: even in an ideal physical habitat, the plant could not survive without its pollinator, and the pollinator would be endangered if the plant disappeared.

J. A. Powell

Other obligatory interactions are not as apparent. The red-cockaded woodpecker (*Dendrocopus borealis*) requires old, dying longleaf and loblolly pines for nesting and is threatened with extinction because mature trees of these two species are replaced with young pulp trees. Longleaf pine itself seems to thrive only in association with a ground cover including wiregrass (*Aristida stricta*), apparently because this grass species facilitates the fires that the pine needs for germination and seedling survival. Because wiregrass propagates almost exclusively by stolons, rather than by seed, it recolonizes an area very slowly once removed. In fact, cleared areas that were originally longleaf pine and wiregrass often do not return to longleaf pine and wiregrass when left unmanaged; instead, other pines and grasses dominate the new community. Consequently, the ecological dependence of longleaf pine on wiregrass partly explains the conifer's current scarcity.

In the 19th century, during the infancy of ecology, scientists focused primarily on each species' needs with respect to the physical environment. In the early 20th century, this concern with habitat requirements was largely supplanted by an overriding interest in interactions among species and the forces that unite them into communities. The resulting holism suggested that the question of what a given species needs for its continued existence is at once trivial (it requires its community) and unreasonable (a species by itself is neither viable nor interesting). The emphasis on a species' community role was healthy, since it caused the realization that plants and animals do not exist in isolation and that appropriate physical habitat is not sufficient for their survival. It also fostered study of entirely new subjects, like materials cycling and energy flow. On the other hand, holism discourages study of individual species' needs,

Wilderness Graphics

Any species' survival kit includes species on which it depends. The California yucca moth (left) lays its eggs in and pollinates Yucca whipplei *in a species-specific, symbiotic relationship. (The dark moth behind it is a parasite, not a pollinator.) The endangered red-cockaded woodpecker (above) requires old longleaf and loblolly pines for nesting.*

since it suggests that each species can be understood only in the context of a long and expensive study of the much larger community.

Fortunately, in the past decade a more balanced emphasis has evolved. Study now focuses on both entire communities and on the ecology of individual species, including their physical habitats and important interactions with other organisms. In other words, the popular synopsis of all ecology in the phrase, "you can't change just one thing," has been superseded by the realization that you can change some things, although probably not too many. Moreover, difficult but feasible research is required to know just what you can change and still allow a given species to survive.

There are several reasons why small populations are unlikely to survive. One is a genetic phenomenon known as "inbreeding depression." In very small populations, there is a high probability that mates are related, and matings of related individuals tend to produce two effects. First, all individuals of diploid species (having a double set of genes, each parent contributing one set) carry several genes that would cause sterility, debilitation, or even death if they were expressed. Offspring of unrelated parents rarely receive copies of the same deleterious genes from both parents. Deleterious genes received from one parent are "recessive": they are masked by normal genes received from the other parent. But when parents

Russell A. Mittermeier

A diaphragm defect found in the endangered Brazilian golden lion tamarin (above) may be related to "inbreeding depression," which occurs when a species' numbers drop beneath a critical minimum.

THE THIRD SURVIVAL requirement for a species, a large enough population size to minimize the likelihood of extinction, probably has been studied least. Whereas habitat needs and interactions with other species must be studied anew for each species, one hopes for general guidelines on how large a population ought to be if it is to succeed. Can we make any predictions, when faced with a newly threatened species, about how many individuals must be maintained?

are related, there is a high probability that they will *both* transmit the same deleterious gene to an offspring. So a population with many consanguineous matings produces many unfit individuals. A diaphragm defect that occurs in the Brazilian golden lion tamarin (*Leontopithecus rosalia*) seems to be caused by such a gene. Since this tamarin's captive populations are so small (few remain in the wild), the incidence of the disease is probably increased by inbreeding.

There is an even more important aspect of inbreeding depression. An individual is "heterozygous" for a gene when the copies of the gene it has received from its parents are different from one another. Individuals heterozygous for more genes tend to be more fertile and to have healthier offspring, regardless of the presence or absence of genes coding for debilitating diseases. Heterozygosity is obviously lower in a smaller population, so its members tend to be less fit and fertile.

Although most plants and animals seem to suffer inbreeding depression in small populations, there is no single threshold population size for all species. Some species seem to tolerate smaller population sizes than others before manifesting severe inbreeding effects. Plants may, on average, require fewer individuals than animals would to minimize inbreeding depression. A consensus among geneticists is that 50 to 500 individuals would likely be required on theoretical grounds, but this is a rough estimate and needs refinement for each species. Inbreeding depression is greatly alleviated by even limited breeding between individuals of separate populations. Just one interpopulation mating every few generations helps counteract genetic problems.

Other forces, all acting randomly, also place very small populations at great risk. Irregular fluctuations in predator, parasite, or pathogen populations, or in the physical habitat, may cause extraordinary mortality in some years; so a population must be sufficiently large to persist. Thus, inbreeding depression and various biotic and physical forces all dictate three demographic requirements for species' survival. First, total numbers of individuals of a species must be substantial. Second, individual populations should not be too small. Third, occasional interpopulation mating may be useful. However, there is no evidence that the optimal or even the necessary conservation approach is to maintain all species in a single or a few enormous populations in large refuges. Although such concentrated populations minimize inbreeding depression, they certainly place the species at greater risk to catastrophes. The now-extinct heath hen (*Tympanuchus cupido cupido*) declined in the Northeast until fewer than 100 birds remained, all on Martha's Vineyard. A refuge established there allowed the population to increase to 2,000 individuals; but a fire, an unusually high number of predatory goshawks, and disease reduced numbers to below 100 again, after which inbreeding depression became severe. Fire, predation, and disease would not have wreaked such havoc had there been several smaller populations instead of one large one.

There are possible genetic benefits to maintaining several smaller populations, though inbreeding depression would always be a concern. Local populations develop genetic differences as they evolve adaptations to their local environments. Their different genes may allow the species as a whole to adapt to environmental change, and, if there is some interbreeding between populations, mixing somewhat different genetic stocks may counter inbreeding depression.

WHATEVER MAY BE THE MINIMUM number of individuals a species needs to survive, and whatever its optimal arrangement among local populations, different *amounts* of habitat are required to support equal populations of different species, assuming appropriate habitat is available. A pair of breeding ivory-billed woodpeckers (*Campephilus principalis*)—with their specialized feeding requirements—needed about 3,800 acres; so 50 pairs required 300 square miles. Animals near the top of the food chain generally require large areas per capita.

On the other hand, many species of plants and animals surely can survive in much smaller areas, provided the physical habitat is optimal and obligatory interacting species are present. Texas wild rice (*Zizania texana*) lives on only 1.5 miles of the upper San Marcos River in Texas, restricted by its

Robert W. Parvin

Nationally endangered Texas wild rice in its only known habitat: a 1.5-mile stretch of the San Marcos River.

Marv Poulson

Gold cottonwoods and gray shale in Utah's Uinta Basin. A number of plant species are restricted by complex habitat requirements to distinct rock strata of the Green River shale formation.

requirement for high alkalinity and narrow temperature fluctuation. This species was probably never widespread, and it has persisted thus for millennia. There is no reason to think it will not persist for many more, so long as its habitat is rigorously protected.

In the Green River shale of the Uinta Basin in Utah and Colorado, many plants are restricted—apparently by precise soil chemistry and drainage requirements—to narrow rock strata covering fractions of a square mile. Among these are the columbine *Aquilegia barnebyi,* the beardtongue *Penstemon grahamii,* and the milk-vetch *Astragalus lutosus.* These species were likely always narrowly restricted. If the existing habitats are preserved, we can be optimistic that the plants will survive—even though the sites are small.

Many animals have similarly narrow ecological requirements, suggesting that they have always existed in small populations. If the sites satisfying these requirements are maintained, extinction will probably take eons.

However, if their habitat is destroyed, such narrowly distributed species can be extinguished swiftly and completely. A mosquitofish, *Gambusia amistadensis,* was discovered in 1968. It was restricted to Goodenough Spring near the Rio Grande in Texas. That same year, a newly constructed reservoir inundated the spring, silted the water, and destroyed the entire natural population of this species.

Some species, then, do not require a Yellowstone- or Yosemite-sized refuge for survival. Others, especially large predators, may need huge areas. But all species need appropriate habitats sufficient to maintain populations large enough to counteract inbreeding depression and chance environmental catastrophes. They also require the presence of certain other species—species with which they must interact to survive. The task of determining which interacting species are crucial, what habitat is appropriate, how large populations must be, and what area is required to sustain them is formidable; but it is critical if we are to make scientifically sound conservation decisions.

Daniel Simberloff is professor of biological science at Florida State University. His fields of expertise are ecology and biogeography, and he has had numerous papers published on statistical ecology, biogeography, and the interactions between insects and plants.

ECOLOGY FORUM

No. 51
by Thomas Eisner
Jacob Gould Schurman
Professor of Biology
Cornell University

CHEMICALS, GENES, AND THE LOSS OF SPECIES

Species extinction has rightfully been called the silent crisis of our time. Estimates tell us that something on the order of one million species may be lost in the next few decades. This is the direct consequence of habitat destruction, which is proceeding worldwide at an ever-increasing pace. Only global conservation programs can slow that pace, and political opposition remains formidable.

To combat the argument that habitat preservation is economically counterproductive, conservationists have pointed to the importance of wild species as the gene banks of tomorrow. As a *chemical* ecologist, I see species as the repositories of organic molecules—and their preservation as critical to meeting the chemical needs of tomorrow. Organic chemistry, we tend to forget, deals with the chemistry of living things. True, the organic chemist is essentially a laboratory scientist; but the molecules he or she studies, identifies, synthesizes, and produces variants of are—for the most part—molecules derived from nature. To the organic chemist, nature is a treasure trove.

We also forget the enormous extent to which we, as a species, depend upon this treasury. Many of the chemicals in everyday use in our culture are natural products, or derivatives of natural products, that owe their existence not so much to the chemist as to the animals and plants that "invented" them. The organic chemist discovers molecules and fashions them for human use. But the inventive genius, more often than not, resides with nature itself.

The chemical exploration of nature has just begun. Large numbers of natural products have been isolated by chemists, yet the total so far is but a small fraction of what nature holds in store. Most plants and animals have never been studied chemically. Figures pertaining to one class of compounds, the alkaloids (almost exclusively derived from plants), are indicative. Extraordinarily diverse in structure and biological activity, thousands of alkaloids have been characterized chemically and hundreds found to have practical uses. They include analgesics, narcotics, anesthetics, insecticides, parasiticides, antimalarial and antiamoebic agents, vasodilators, vasoconstrictors, antihypertensive agents, muscle relaxants, anticholinergic and cholinergic agents, respiratory stimulants, and gout suppressants—to name only a few. (Some of the most effective recently discovered anticancer drugs are alkaloids as well.) About 5,000 flowering plants have been analyzed for the presence of alkaloids, but this is a mere five percent of the one-quarter-million species of flowering plants we estimate to exist.

Most beneficial chemicals are yet to be discovered. Lower plants, including fungi and other microorganisms in their astonishing variety (especially in the tropics), remain largely unstudied—even though they have so consistently proven to be the source of new natural products. The recent discovery of ivermectins provides a good example. These compounds, isolated from a *Streptomyces,* show great promise for use against livestock parasites (nematodes and arthropods), that cause billions of dollars of losses annually in the U.S. alone.

Among animals, the invertebrates are largely unstudied but already a documented source of chemical wealth. Anticancer agents have recently been isolated from little-known marine invertebrates; and we ourselves, in our collaborative work with chemists on insects, millipedes, and other arthropods, have come upon heart stimulants, neurotoxins, insect repellents, and other biologically active substances. Chemical prospecting among species is still very much in order.

Major advances in recent years greatly facilitate the search for natural products. First, procedures have been developed by which new chemicals can be isolated cleanly and often quickly from the complex mixtures in which they occur naturally.

Secondly, highly sensitive spectrometric instruments now available permit a natural product to be characterized on the basis of minute samples. The net effect is that large quantities of starting material are no longer required. Amounts obtainable from only a few animals or plants (sometimes even from a single specimen) may suffice.

This has important consequences: chemical prospecting can now be carried out on small organisms (like many of the lesser-known invertebrates) or on rare organisms (including many plants) that exist in small, patchily distributed populations. Rare organisms could be of special interest since rarity may be a sign of chemical protectedness. The very fact that they have managed to hold on may mean they're armed—with repellents, toxins, antibiotics, antihelminthics—against predators and parasites. These substances often have practical uses.

Chemical prospecting does not necessarily lead to the massive "mining" of organisms found to be carriers of novel compounds. If it did, and if such organisms were rare, discovery could be devastating for the species. But the usual follow-up to discovery is an attempt at chemical synthesis. Then, if the compound is needed on a large scale, it may be laboratory-produced without recourse to nature. True, environmental harvesting may still be a tempting expedient for the industrial chemist in some cases, and conservationists may need to remain watchful here, but chemical prospecting *per se* should be encouraged as long as it is carried out on limited samples. The activity is clearly to the common good—a common good to which species extinction poses a great threat. Chemical prospecting, even at accelerated rates and with technological improvements, cannot possibly keep pace with the projected rate of species extinction. We are becoming chemically impoverished by the loss of a vast resource base, one that is shrinking more quickly than we can hope to assess it. To both the chemical and pharmaceutical industries, this should be of great concern.

Today, chemical prospecting is carried out by chemists and ecologists working in collaboration. The result is that discovery of new compounds is often accompanied by discovery of new biological roles for such compounds. Ecologists are becoming increasingly aware of the subtleties of chemical interaction of organisms in nature and of the literally infinite roles natural products may play. Organisms protect themselves chemically; they attract and assess their mates chemically; they interact chemically with their offspring; they may even monitor the activities of other organisms by "eavesdropping" on chemicals that these produce.

Compounds that mediate such activities sometimes turn out to have practical use. But very often they do not and are judged "esoteric" and of basic scientific interest only. Could such judgment be premature? Some insect repellents produced by plants, although protective to the plants that make them, cannot be used commercially for crop protection because they are too volatile or unstable—or too toxic to be generally applied to a crop. But imagine if one were able to convey upon a crop plant the genetic capacity to produce such repellents. Imagine being able to transfer appropriate genes from a chemically protected plant to one that is vulnerable, such that the recipient is then able to produce the defensive chemicals of the donor. Might this not be an ideal way to achieve plant protection? Does it make sense to envision a day when, say, genes from a chemically protected mint plant (mints produce terpenoid compounds that are strongly repellent to insects) might be transferred to cotton, rice, potato, or some other insect-plagued crop?

Gene transfer, the essence of genetic engineering, was only a remote possibility some years back. Today genes can be transferred between microorganisms; they are proving transferable between some animals; and one can glimpse the chance of their eventual transfer from plant to plant. Genetic engineering casts new light on our environmental value judgments and on the worth of species that we are losing to extinction. Species can no longer be viewed simply as unique conglomerates of genes. They must be viewed as repositories of individual genes—and therefore of individual genetic capacities, including chemical capacities—that are potentially transferable. An obscure plant on its way to extinction as a consequence of human encroachment upon the Amazonian rain forest may thus represent more than just another "esoteric" species worth saving. It could be the source of new chemicals of potential usefulness—and eventually, perhaps, a donor or recipient in a genetic transfer. Conveyance of anti-insectan capacities is just one example of what one might wish to accomplish through genetic modification of a plant.

In theory, there is no limit to the kind of chemical capacity, or other phenotypic capacity, that might be bestowed upon an organism through gene transfer. The tide of extinction must be stemmed if we are to draw upon this potential. But regardless of how fully genetic engineering lives up to its promise, species should be saved to meet another need: the need to explore the untapped chemical reserves of our natural world.

Dr. Thomas Eisner *appears in "The Garden of Eden"—a new conservation film produced by the Conservancy thanks to a grant from the Continental Group. See enclosed brochure.*

NEW PROJECTS

ALABAMA

Mobile-Tensaw Delta Wildlife Management Area (Baldwin and Mobile Counties). An 18,000-acre expanse of bottomland hardwood forest and coastal marsh has been purchased by the Mobile-based Coastal Land Trust with Conservancy assistance. The Mobile-Tensaw Delta was targeted for protection within the Conservancy's Rivers of the Deep South Program (initiated by a $15-million Richard King Mellon Foundation challenge grant three years ago) along with five other river systems: the Pearl and Pascagoula in Mississippi and the Choctawhatchee, Apalachicola, and Suwannee in Florida. More than 112,000 acres have been safeguarded under the program to date.

CALIFORNIA

Baldwin Lake—Addition—(San Bernardino County). Two purchases totaling 27 acres extend protection for the world's largest undisturbed stretch of "pavement plain." The earth here at the north end of Big Bear Valley's boot-shaped Baldwin Lake—a mix of alkaline clay and cobbles of sarragossa quartz found only in this part of the San Bernardino Mountains—was pushed up to the surface by freezing and thawing in the Pleistocene. It fosters the growth of 14 plant species listed as rare and endangered by the California Native Plant Society. Eleven of these are endemic to the area, including slender-petaled mustard and Big Bear checkerbloom, both of which are proposed for federal listing as endangered. A top priority of the California Critical Areas Program, Baldwin Lake hosts a sizable wintering population of migratory waterfowl as well as nationally endangered bald eagles. The California Field Office manages the preserve, now 124 acres all told.

FLORIDA

Lower Suwannee River National Wildlife Refuge—Addition—(Levy County). Conservancy projects on the lower Suwannee date back to the early 1970's and span well over 6,000 acres. Recent purchase of an additional 11,885 acres under the Rivers of the Deep South Program protects excellent examples of numerous communities (tidal marshes, floodplain swamps, and several upland habitats). A corridor for migratory birds and a prime nesting area for the uncommon swallow-tailed kite, this section of the river also supports summering West Indian manatees—endangered mammals the Conservancy has worked long to protect. Part of the land will be conveyed to the Suwannee River Water Management District—the rest to the U.S. Fish and Wildlife Service, which will manage both portions within its refuge.

MAINE

Rachel Carson National Wildlife Refuge—Addition—(York County). Another generous gift of land from George and Ann Cochrane, this 40-acre woodland tract bordering the Mousam River's floodplain is charted for transfer to the U.S. Fish and Wildlife Service. The land will be added to the Mousam River Unit of the nearby refuge (the second largest national wildlife refuge in the state) as was a previous 110-acre gift from the same donors.

Northwest Head (Washington County). In 1980, the Maine Chapter acquired 1,355 acres on the Cross Island archipelago in Machias Bay (a gift of Mr. and Mrs. Thomas D. Cabot), then transferred the land to the U.S. Fish and Wildlife Service for refuge management. The recent purchase of 130 acres off the western shore of Cross Island itself spells protection for the last link in the assemblage: a haven for nesting bald eagles and numerous waterfowl species. Northwest Head, forested land connected to Cross by a narrow cobble bar and salt marshes, provides roosting and feeding habitat for the eagles. It is a project of the Maine Chapter's ambitious $610,000 "Islands of Life" campaign. All donations will be matched, dollar for dollar, up to $305,000.

MINNESOTA

Saxifrage Hollow (Fillmore County). Put your hand on the ground here and you'll feel the cold issuing from fissures in the limestone bedrock. Purchase of four acres on this north-facing talus slope above the Root River brings Conservancy protection to the peculiar microclimate, site of one of Minnesota's few viable populations of the Iowa golden saxifrage (*Chrysosplenium iowense*), currently under review for federal listing. The Minnesota Chapter has a fund-raising goal of $25,970 for the project.

MISSOURI

Poverty Ridge Savanna (Laclede County). Though dry oak-hickory savanna-land was once common in Missouri, little remains. A newly purchased 120-

F. William Burley

Big Morongo Canyon

There's a new management "umbrella" over one of southern California's most extensive and biologically diverse desert oases. By establishing agreements with San Bernardino County and the U.S. Bureau of Land Management (BLM), the Conservancy has brought 3,840 acres adjacent to its own 80-acre preserve under cooperative protection: a 140-acre portion of the county's Big Morongo Wildlife Reserve and the 3,700-acre federally owned Big Morongo Area of Critical Environmental Concern. The benefit to the ecosystem is an integrated program for visitor use, trail planning, biological monitoring, and maintenance.

Named for its last presettlement inhabitants (the Morongos, a powerful clan of the Serrano Indians), the canyon bears a *desert-springs ecosystem*—one of 11 jeopardized ecosystems charted for protection under the highly successful California Critical Areas Program. Its lushness stands in sharp contrast to surrounding desert slopes. A high water table has allowed tall trees to take hold despite the area's scarce rainfall: an average of just eight inches a year.

Embracing two desert vegetation zones, the Mojave and the Sonoran, the canyon provides food, cover, and water for some 300 bird species—both residents and migrants. The least Bell's vireo, listed as endangered in the state, nests here; and several birds of southern Arizona and northern Mexico (summer tanager, vermilion flycatcher, and brown-crested flycatcher among them) occur at the northernmost extension of their ranges. Mammals and reptiles are abundant—from desert bighorn sheep, which water in the area, to San Diego horned lizards, a species under review for state protection.

The California Field Office and the Big Morongo Canyon Preserve Committee will manage the oasis in concert with the county and the BLM under the terms of the new agreements.

acre tract near Bennett Springs State Park constitutes the state's only protected example. Prairie plants—including rattlesnake master, catclaw sensitive briar, Virginia tephrosia, leadplant, and switch grass—abound beneath the open canopy of trees. The Missouri Chapter, which manages the new preserve, must raise $57,584 to match (on a two-to-one basis) Goodhill Foundation funds granted through the Conservancy's National Critical Areas Conservation Program.

MONTANA

Swartz Lake (Lake County). In spring and fall, this shallow mountain lake and surrounding western red cedar/Douglas fir forest are prime habitat for *Ursus arctos horribilis,* the nationally endangered grizzly bear. At one time grizzlies roamed prairies, forests, and foothills from the Pacific Coast east to the Mississippi River and south to Mexico; today, in the contiguous 48 states, only some 800 (of an original population of more than 100,000) hold on in a small portion of the northern Rockies. The Mission Mountains, where Swartz Lake lies, host a semi-isolated group of no more than 25 animals. The Montana/Wyoming Field Office plans to transfer a 160-acre Potomac Corporation gift of land here to the Confederated Flathead Kootenai Salish Tribes for protection within the Flathead Reservation.

NORTH CAROLINA

Nags Head Woods—Addition—(Dare County). A management agreement on 24 acres in the northern portion of the preserve brings Conservancy-protected acreage here on Roanoke Sound to 639. A national natural landmark lodged among the back barrier dunes of North Carolina's Outer Banks, this maritime forest ecosystem—where northern and southern plant species *coexist,* many at their geographic limits—was fostered by the convergence of warm Gulf Stream waters and cold currents from Labrador. Its spectrum of wetland communities (freshwater ponds, swamp thickets, subterranean reservoirs, brackish marsh) and its oak-hickory forest harbor a number of state-endangered birds and plants. This "national critical area" is managed by two professional Conservancy preserve stewards.

OHIO

Abner Hollow—Addition—(Adams County). Continuing its efforts to expand the Edge of Appalachia Preserve System, the Ohio Chapter has assisted the Cincinnati Museum of Natural History in purchasing a key 330-acre inholding. The parcel links Abner Hollow to the Rieveschl Preserve and controls access to the southern end of the assemblage. The Edge of Appalachia area—riddled with steep gorges, artesian springs, and dolomitic promontories—is noted for its extraordinary botanical diversity and the numerous state-protected species it supports. The museum owns and manages the land.

Battelle-Darby Creek Metro Park (Franklin County). The Ohio Chapter has assisted the Columbus and Franklin County Metropolitan Park District in purchasing a critical 101-acre inholding for addition to its 2,100-acre park southwest of Columbus. The tract ribbons a half-mile of Big Darby Creek itself, a high-quality stream with a healthy, diverse aquatic fauna. Its waters support 40 species of mollusks (from the family *Unionidae*) and the world's only known population of the nationally endangered fish Scioto madtom, as well as ninety other fish species. The park district owns and manages the property.

TENNESSEE

Goose Pond (Grundy County). Breeding habitat for four bird species listed as threatened or endangered in the state by the Tennessee Natural Heritage Program (American bitterns, least bitterns, purple gallinules, and king rails), this 90-acre freshwater marshland is protected through a cooperative management agreement between the Tennessee Chapter and the landowners. Set in uplands at the foot of the Cumberland Plateau's western escarpment, the marsh exemplifies an extremely rare community type for this physiographic province.

A Gift of Membership

Have you ever considered membership in The Nature Conservancy as a thoughtful gift for a friend?

That special person will remember your kindness with each issue of *The Nature Conservancy News.* The membership will acquaint your friend with the urgent and interesting programs the Conservancy sponsors. It may well kindle an interest in the Conservancy similar to your own. And it costs less than a good necktie or a flacon of perfume—just ten dollars!

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For information in full confidence about including a bequest to The Nature Conservancy in your will, or for sample bequest language for review by you and your attorney, please contact Alice A. Pinsley at the Conservancy's Boston Office (see address in box above).

VISIT A MONTANA RANCH

Join us next summer and explore the Conservancy's extraordinary Pine Butte Swamp Preserve—spectacular surroundings for riding, hiking, fishing, photography, birdwatching . . . or just relaxing.

Al and Sally Haas invite you to stay at a unique dude ranch in the heart of Montana's Rocky Mountain Front. For more information, contact the Circle 8 Ranch, P.O. Box 457, Choteau, Montana 59422. Phone: (406) 466-5564.

COTTAGES AVAILABLE AT MILE HI

Modern housekeeping cottages overlooking a mountain creek are available for rental year-round at the Conservancy's Mile Hi Preserve. Located 90 miles southeast of Tucson in the Huachuca Mountains, the Mile Hi stretches across the mouth of Ramsey Canyon, one of the loveliest and most biologically diverse canyons in southern Arizona. To arrange a visit or obtain a brochure and bird list, write: The Mile Hi, RR 1, Box 84E, Hereford, Arizona 85615. Phone: (602) 378-2785.

FIELD COURSES IN THE PACIFIC NORTHWEST

Lying at the interface between Oregon's Cascade Range and the Great Basin, the Conservancy's Katharine Ordway Sycan Marsh Preserve will be the site next summer of beginning and advanced ten-day field courses. Studies will embrace botany, general natural history, and ornithology. Excursions will take in vast alkaline lakes, volcanic mountains, sage deserts, forests of pine and fir, and freshwater marshes hosting some 200 breeding greater sandhill cranes.

Transportation, meals, and facilities (tents) for staff and nine participants per session will be provided. For further information, contact: Sycan Education, The Nature Conservancy, 1234 Northwest 25th Avenue, Portland, Oregon 97210. Phone: (503) 228-9561.

NEXT IN THE NEWS:

COSTA RICA

The January/February issue looks at a Central American nation whose conservation achievements make it a model and an inspiration. Read about the Conservancy's International Program and its work in Costa Rica—next in the *News*.

Oak Leaf Awards 1982

Once a year The Nature Conservancy acknowledges the outstanding efforts of its members through the presentation of the Oak Leaf Awards. This award, symbolized by a green and gold lapel pin, is given in recognition of especially dedicated service and support toward achieving the Conservancy's objectives.

As the Conservancy's first national director of membership development, **Thomas Beers** raised the organization's membership from 30,000 in 1977 to more than 135,000 in 1982—a dramatic 350 percent increase in only five years. Working essentially on a full-time volunteer basis, Mr. Beers created an outstanding membership program and made an immeasurable contribution to the Conservancy.

While chairman of the Board of Governors, **Wallace C. Dayton** led in creating the Conservancy's Land Preservation Fund, which provides money temporarily, but quickly, to acquire imperiled natural areas. He was also instrumental in furthering the Conservancy's effort to accept gifts of properties without ecological significance for subsequent resale; the proceeds are applied to protecting critical *natural* lands.

Richard Duffield was chairman of the Conservancy's Arizona Project Committee in the early 1970's. During that period, his leadership was essential to acquiring the Canelo Hills Cienega and Ramsey Canyon preserves. Mr. Duffield is currently legal advisor to the Arizona Chapter.

While chairman of the Ohio Chapter's Board of Trustees from 1974 to 1976, **William W. Ellis, Jr.,** guided the chapter in completing five major land acquisitions. More than 1,000 acres valued at over $6 million were saved in 1975 alone—a record year in the chapter's history. Chairman of the Pickering Pond Committee, Mr. Ellis has directed the negotiations involved in this complex project.

Dr. Robert E. Frenkel has successfully transformed and improved nearly every aspect of the Oregon Natural Heritage Program. As a member of the Oregon Chapter Board and through many hours of volunteer service, he acted as scientific liaison for the state's stewardship program and helped the heritage program to conduct a riparian analysis in the Willamette Valley. Dr. Frenkel also assists in managing Cox Island.

James Gordon Hanes, Jr., is responsible for forming the North Carolina Chapter's original Board of Trustees and served as its first chairman from 1977 to 1979. His assistance and generosity to the project fundraising efforts of the North Carolina Nature Conservancy have been invaluable.

As a member of the New Mexico Chapter Board of Trustees, **William S. Huey** was instrumental in establishing the state's natural heritage program. In addition, he guided negotiations for the cooperative acquisition of the Edward Sargent Fish and Wildlife Area by the Conservancy and the New Mexico Department of Game and Fish.

Warren B. Lammert, Sr., has worked tirelessly to preserve ecologically important areas in Missouri, especially by promoting and assisting in the creation of the Design for Conservation Program. The program provides the Department of Conservation with $40 million each year to acquire and manage natural lands and public recreation areas. As a vital member of the Missouri Chapter's Board of Trustees, Mr. Lammert has also volunteered time and expertise to design brochures and fund-raising material for the Conservancy.

Dr. Mary-Parke Manning is one member of a small group of people dedicated to preserving New York's Thousand Acre Swamp. She is an advisor to and member of the preserve committee and has devoted countless hours over the past seven years to local fundraising for the sanctuary.

A hard-working volunteer for over ten years, **Mary Elizabeth "Bonnie" Mitsui** has conducted land appraisals for the California Critical Areas Program, organized field trips and fund-raising events, and acted as hostess for Conservancy receptions and annual meetings. She played a key role in protecting such ecologically significant areas as Idaho's Silver Creek and Jepson Prairie, California.

Nathaniel P. Reed has served The Nature Conservancy with distinction for more than 15 years. As a member of the Board of Governors from 1976 to 1982, he co-chaired the historic Bicentennial American Land Trust, the foundation of the Conservancy's highly successful Corporate Relations Program. Mr. Reed was also instrumental in establishing a Conservancy state office in Florida, and he recently headed the acquisition campaign for the Crystal River Manatee Sanctuary.

Dr. Edward B. Seligmann, Jr., has been vice chairman for stewardship for the Maryland Chapter since 1980. Under his vital leadership, the Maryland Chapter has established a comprehensive and effective stewardship program in the state. Dr. Seligmann is an indefatigable, meticulous worker and a dedicated Conservancy volunteer.

An active member of the Connecticut and Florida Chapters for many years, **Richard S. Weinstein** has also served for ten years on the Conservancy's Board of Governors. He has volunteered his legal expertise many times to evaluate difficult negotiations and complex land acquisitions.

Charles A. Wellner paved the way for Conservancy/Forest Service cooperation in setting aside ecologically critical lands in Utah and Nevada. As chairman of the Idaho Chapter's Board of Trustees, he has been responsible for the preservation of natural areas in that state as well. Moreover, many of the northwestern state's heritage programs have benefitted tremendously from Mr. Wellner's early work in developing a habitat-type classification system.

Harry L. Willard is one of the original trustees of the South Fork/Shelter Island Chapter. While chairman of the chapter board from 1976 to 1982, he led the effort to acquire Mashomack Preserve and additions to Atlantic Double Dunes. During his tenure, South Fork/Shelter Island preserves grew from 360 acres to 2,452 acres.

While **John R. Womer** was chairman of the Indiana Chapter from 1979 to 1982, the chapter was named the Conservancy's most outstanding in 1980. Mr. Womer also established the Moraine Nature Preserve, an exemplary project, and he serves as a preserve steward.

International Award Winners: Mario A. Boza and **Alvaro Ugalde** are pacesetters in preserving the tropical diversity of Latin America. Mr. Boza was the first director of Costa Rica's National Parks Service; Mr. Ugalde is the current director. Through their leadership, Costa Rica has protected over 1 million acres in a system of 22 national parks and biological reserves. These areas include the national parks of Corcovado, Tortuguero, and Santa Rosa. With only 35 percent of Costa Rica's original forest cover remaining, the Conservancy is working with the country's National Parks Foundation to promote its vitally important five-year fund-raising campaign.

Stewardship Awards

It is estimated that more than 5,000 volunteers are engaged in the stewardship of Conservancy preserves. The President's Stewardship Award is presented to at least one committee and one individual that have contributed significantly to the advancement of the art of stewardship on Conservancy preserves.

The Cascade Head Preserve Committee initiated the fund-raising drive to acquire Cascade Head, Oregon. Moreover, committee members have created the preserve's management plan, established an education and research program, prepared preserve brochures and trail guides, and cared for the area on a daily basis.

Dr. Jeffrey Black and Mr. Donald Russell are responsible for the preservation of Charley Owl Cave in Oklahoma. They brought the cave to the Conservancy's attention and designed and implemented a management plan for the entire 90-acre area. Thanks to their day-to-day stewardship of the cave, the nationally endangered gray bat once again summers in Charley Owl: the cavern supports one of the state's largest maternal colonies of the beleaguered bats.

NEW LIFE MEMBERS

An individual becomes a Life Member of The Nature Conservancy upon contribution of $1,000 for membership dues or for the Land Preservation Fund, Guarantee & Income Fund, or a State Land Preservation Fund. Husbands and wives may hold a joint life membership for a single qualifying contribution.

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